Biogenic Ripple Destruction: Rates, Modes and Subsurface Consequences

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LONG-TERM GOALS

The ultimate objective of this research program is to obtain a predictive understanding of the physical and biological processes that control the microtopography of the sediment-covered seafloor. Our primary means to address this topic is to make focused field measurements that extend and test conceptual frameworks.

OBJECTIVES

This project, part of the "Ripple DRI", had as its goal the quantitative measurement of ripple destruction rates and modes, as well as their subsurface consequences. It is important to develop a predictive understanding of ripple destruction for at least two reasons. First, in many environments where ripples occur they are ephemeral features. That is, the near-bed flows are of insufficient magnitude to move sediment continuously as bed load (a prerequisite of ripple formation and maintenance). During the periods between sediment transport events, ripples in most settings will be subject to biogenic destruction, and all of the physical, chemical and biological consequences of the ripples will be altered or cease to occur altogether. Second, under weak transport conditions ripple geometry likely depends on the preceding bed morphology (i.e., the seabed has a memory, Fries et al. 1999). Thus, without better knowledge of the evolution of ripple geometry during non-transport periods (i.e., during the destructive phase) it will be more difficult to predict morphology when the flow increases above the critical shear stress (the constructive phase). The second general but related area of inquiry in this project involves ripples as templates for subsurface structure. By "templates" we mean that ripples, because they perturb near-bed and subsurface fluid and particle fluxes (e.g., Huettel et al. 1996), may cause repeatable subsurface variations in diverse properties, especially bulk density.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 2005**	2. REPORT TYPE	3. DATES COVERED **00-00-2005 to 00-00-2005**

4. TITLE AND SUBTITLE **Biogenic Ripple Destruction: Rates, Modes and Subsurface Consequences**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Oregon State University,College of Oceanic & Atmospheric Sciences,Corvallis,OR,97331**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S)
	11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
code 1 only

14. ABSTRACT
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15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

APPROACH

Our focused set of field measurements at the SAX04 (Ft. Walton Beach, FL) and nearby sites was to include:

(1) deliberate, noble-metal tracer experiments to quantify horizontal and vertical biodiffusivities in the presence/absence of transient bioturbators (fish),

(2) time-series measurements of ripple profiles using a diver-operated laser system, and

(3) high-resolution vertical profiles of porosity using an *in situ* resistivity probe (Wheatcroft, 2002). The first two measurements were designed to test a simple model relating ripple destruction rate to the intensity of horizontal bioturbation, whereas the latter measurement extends results obtained during SAX99 that suggest ripples may yield deterministic porosity patterns in the subsurface.

WORK COMPLETED

Our field measurements were wholly dependent on divers. Therefore, the nearby passage of hurricane Ivan on 16 September had major negative effects on our research plan. We were the first divers in the water following the hurricane (on 19 September) and found visibility at the bottom to be essentially zero. Over the next week conditions improved to <0.5 m visibility, but this level still precluded most of our measurements. We returned in late October, when conditions were marginally better (2+ m visibility), but by then could not conduct our tracer or profile measurements. It is important to recognize that there was a very strong vertical suspended-sediment concentration gradient such that water even 2 m above bottom had much higher visibility. Unfortunately, we were working in the lower 0.5 m. All was not lost, however, as we were able to make a large number of resistivity measurements.

RESULTS

Two results are highlighted. First, mud delivered to the study area following hurricane Ivan preferentially accumulated in ripple troughs compared to crests. Therefore, the subsurface porosity (or bulk density) field underlying ripple troughs showed much greater vertical fluctuations (Fig. 1), which has potentially important implications for sound scattering. Second, we detected a clear relationship between the porosity of buried mud layers and the thickness of the overlying sand layer (Fig. 2), whereby thicker sand layers resulted in a more fully consolidated mud.

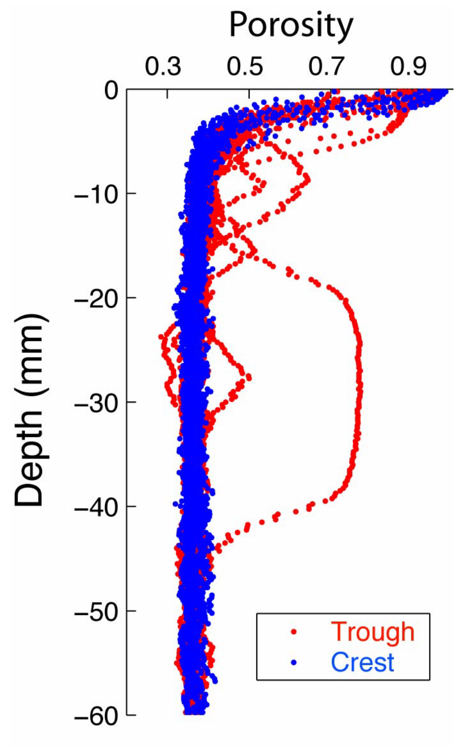

Figure 1. A subset of porosity profiles obtained in situ from the upper 6 cm of the seabed at the SAX04 study site in late October 2004. Profiles collected from ripple troughs had many subsurface fluctuations, whereas profiles from ripple crests did not.

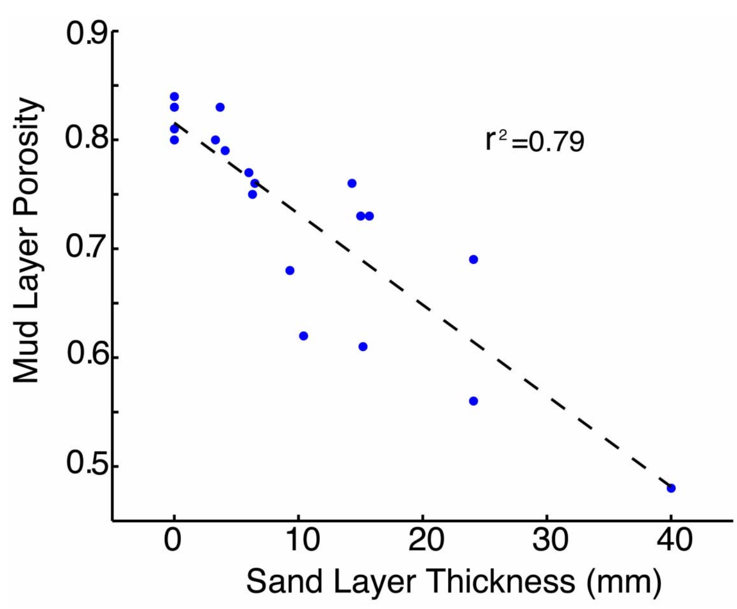

Figure 2. A plot of sand layer thickness (mm) versus mud layer porosity showing a linear relationship (r^2 = 0.79), whereby sand-layer thicknesses of <5 mm resulted in mud porosities of >0.8, whereas a sand layer thickness of 40 mm resulted in a porosity <0.5.

An additional, albeit qualitative, result was our observation that fish abundance was higher adjacent to seafloor structures such as tripods, and the resultant microtopography was more heavily impacted by their foraging activities.

RELATED PROJECTS

Our rippled degradation research is related to that of Richardson (NRL), Boudreau and Hay (Dalhousie). Their acoustical measurements and automaton models of ripple degradation would have benefited from the tracer experiments and our proposed caging experiments that were intended to exclude transient bioturbators. We continue to interact with these colleagues, with the hope of making improved field measurements of ripple degradation in the future. In addition, our resistivity measurements complement those made by Tang (APL-UW).

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